SONIC EQUIPMENT FOR TRACKING INDIVIDUAL FISH

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United States Department of the Interior, Fred A. Seaton, Secretary
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SONIC EQUIPMENT FOR TRACKING INDIVIDUAL FISH

by

Parker S. Trefethen
Fishery Research Biologist

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ABSTRACT

Special sonic devices are being developed for obtaining detailed information on individual fish behavior. A miniature underwater sonic tag is attached to an adult salmon and the movements of the fish are observed on calibrated sonic receiving equipment. The position of the fish can be pin-pointed, and movements plotted for periods of time up to 100 hours. The equipment can be used in varied hydraulic conditions and in fresh or salt water to track the movements of adult fish and other aquatic animals.

The transducer is attached behind the dorsal fin of adult salmon by a nickel-chromium "hog-ring" clamped into the back with special pliers. It is attached underwater without handling or immobilizing the fish. Visual observations indicate that the transducer does not affect the natural movements of an adult salmon.

CONTENTS

	Page
SONIC EQUIPMENT	1
Miniature underwater sonic transducer (sonic tag)	1
Automatic-tracking receiver	4
Portable receiver	5
ATTACHMENT OF TRANSDUCER TO ADULT SALMON	5
Materials and methods	5
Effect on natural behavior	5
USES OF SONIC EQUIPMENT	10
SUMMARY	10
ACKNOWLEDGMENTS	11
REFERENCES	11

SONIC EQUIPMENT FOR TRACKING INDIVIDUAL FISH

The U. S. Fish and Wildlife Service is developing underwater sonic equipment for obtaining a detailed knowledge of the movements of individual adult salmon in relation to Columbia River dams. Each dam on the Columbia River presents a chance for delay in migration with injurious consequences if the delay is prolonged. Since new dams are under construction and in the planning stages, information on salmon behavior in relation to dams is needed for the effective operation of present fish passage facilities and for the design and location of new facilities. Data on adult salmon behavior at dams is scarce because the methods available for obtaining the information have been confined to visual observations which are limited by the turbidity of the water and by hydraulic conditions, and to tagging operations which supply information on the average rates of movement, but no information on the movements of a tagged fish between the point of release and the point of recapture. Use of sonic equipment may overcome these limitations so that the complete movements of individual fish can be tracked under natural conditions in daylight or darkness.

The development of the equipment was initiated by Dr. Gerald Collins, U. S. Fish and Wildlife Service and it was designed and manufactured under contract by the Minneapolis-Honeywell Regulator Company, Seattle Development Laboratory. While the final device has not been completed a practical working model has been produced and is being used to observe fish movements under natural conditions.

Considerable interest has been shown by fishery research biologists in this equipment because it provides a new research tool for studying the behavior of fish and aquatic animals in their natural environment. Since modifications are anticipated to increase the efficiency and accuracy of the present model, this report is a generalized description of the equipment and its potentialities. When the modifications have been completed and the equipment is in the final stage of development, a more detailed technical report will be published.

SONIC EQUIPMENT

The equipment now being developed to track individual fish includes a self-contained miniature underwater sonic transducer or sonic tag and receiving equipment. The sonic tag is attached to a fish (Fig. 1) and the transmitted sound waves are picked up by the receiving equipment. Since the receiver is calibrated in bearing, distance and angle in relation to the sonic tag, the position of the fish can be pin-pointed when desired, and detailed movements of individual fish can be easily plotted.

Miniature Underwater Sonic Transducer (Sonic Tag)

The transducer is essentially an aluminum capsule 2-3/8 inches long and .86 inches in diameter, weighing approximately 2 grams when immersed in water. All of the component parts are contained within the capsule. The 15-volt battery power-source and the electronic circuitry, imbedded in styrene plastic foam, are located between the two ends of the capsule. The transistor is solidly attached in one end of the capsule; the resonating crystal is cemented in the opposite end. The latest sonic tag is shown in Fig. 2 in relation to two earlier experimental models.

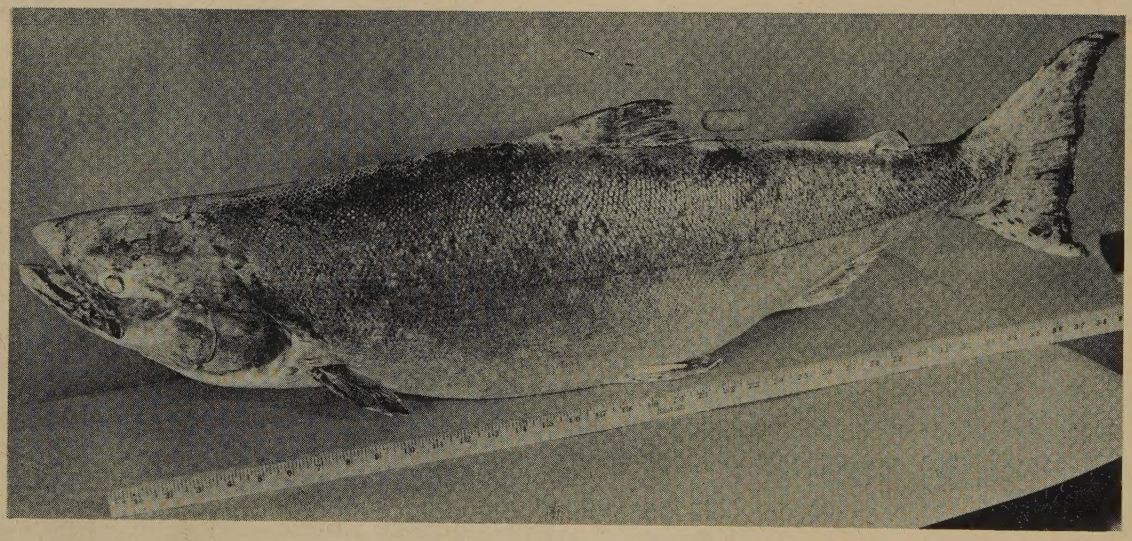

Fig. 1. Sonic tag attached to adult chinook salmon.

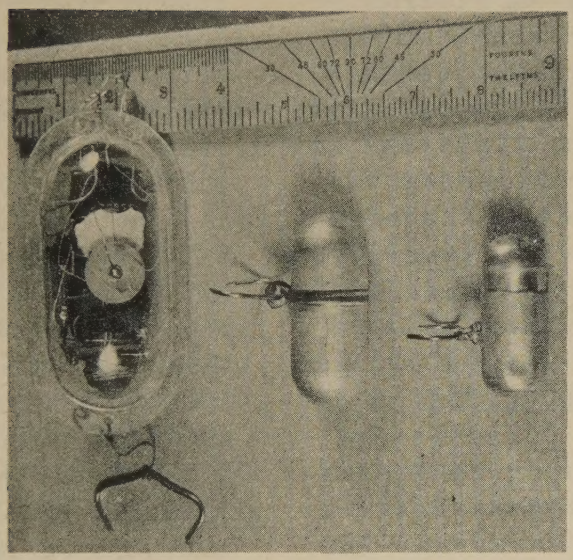

Fig. 2. Experimental underwater sonic tags. Tag now being used is on the extreme right.

In quiet fresh water the sound waves transmitted by the transducer can be detected at distances up to 2,000 feet. In turbulent and aerated water, such as is found close to and immediately upstream of a fishway weir, the distance is reduced to 65 feet. The distances in sea water are reduced by approximately one-third. The length of time during which the sound waves can be detected vary from 10 to 100 hours depending upon the size battery used.

= 132,000 cps

The transducer operates on a carrier frequency of 132 kilocycles per second with a repetition rate of 450 cycles per second. This carrier frequency is slightly higher than the frequency of the ambient water noises and therefore gives the best detection under a variety of hydraulic conditions. An increase in carrier frequency reduces the range at which the sound waves can be detected, especially in turbulent water. A lower frequency would require a crystal of a greater diameter which would necessitate a larger tag. In order to use several sonic tags at the same time, in the same area, the repetition rates of the transducers are adjustable. By using receiving equipment which can be tuned to a desired frequency, the position of up to ten tags can be pin-pointed and identified.

The capsule within which the component parts are fitted is spun in two halves from soft aluminum sheeting .007 inches thick. Before the sonic tag is assembled, the device for attaching the unit to a fish is soldered onto one-half of the capsule. After the component parts have been assembled and secured in place, the two halves are joined and the joint is sealed with an elastic tape. The entire unit is dipped in a clear liquid plastic to make it completely waterproof.

Assembled tags can be stored for a maximum of one year with no serious effect on their operation. When used within a year for tracking a fish, the tag can be made operational by simply twisting together two wires which closes the electrical circuit. These wires protrude through the capsule and through the plastic covering. If it becomes necessary to change the battery, the tag can be easily disassembled and reassembled after the battery has been replaced.

Automatic-Tracking Receiver

An automatic-tracking device was designed and incorporated with an echo-ranging system to produce an automatic-tracking receiver. The automatic-tracking device seeks out and "homes" on the sonic tag attached to a fish, aiming the echo-ranging system in that direction. The echo-ranging system supplies the information on the movements of the sonic tag attached to the fish up to a distance of 800 feet (this is the maximum radius within which the fish can be "tracked", even though, as stated above, they can be detected at distances up to 2,000 feet). Ultrasonic impulses are sent into the water by the system in the form of a narrow beam; returning echoes from the fish supply the information of its position through an indicator unit. The frequency of this beam of sound impulses differs from the frequency of the sonic tag thus creating no interference.

The indicator unit contains a viewing screen, a tilt-angle meter, a loudspeaker and a signal-level indicator plus the operating controls The viewing screen is a calibrated cathode-ray tube on which returning echoes are observed visually as a bright spot of light after conversion into electrical energy. The bearing and distance of the fish can be read directly. The tilt-angle meter shows the angle at which the beam of sound impulses is projected into the water when aimed at the fish. With this information (distance and angle) the depth of the fish can be calculated. The

loudspeaker produces audible signals which aid in the interpretation of the returning echoes. The signal-level indicator shows the strength of the sound waves being transmitted by the sonic tag on the fish and indicates very roughly the distance of the fish from the echo-ranging system. An automatic tracking receiver is shown installed in a Fish and Wildlife Service boat in Fig. 3.

Portable Receiver

Since it is not possible to use the automatic tracking receiver in confined conditions such as a fishway pool, a small portable battery operated receiver was designed to detect the presence of a fish with a sonic tag attached in restricted well-defined areas. This receiver was designed for use with a non-directional listening hydrophone. The hydrophone in the water picks up the sound waves transmitted by a sonic tag and amplifies them through a loudspeaker in the receiver. Earphones can be used when necessary to reduce the interference of outside noises with the signals from the sonic tag. Figure 4 shows a portable receiver and listening hydrophone.

ATTACHMENT OF TRANSDUCER

A method of attaching the sonic tag to an adult salmon was developed to minimize the effect of the tag on the natural movements of the fish. With this technique the tag is attached to a fish underwater, without handling the fish and without immobilizing it.

Materials and Methods

The transducer is attached to a fish by a "hog-ring", 1-1/4-inches wide and 1/2-inch high, fabricated from nickel chromium wire .064 inches in diameter, the ends of which are beveled to a sharp edge. To make a rigid connection with the sonic tag, the ring is first centered in a hole in a brass rivet and silver-soldered in place. The head of the rivet is then brazed to the outside of the tag with aluminum solder. A sonic tag with "hog-ring" is shown in Fig. 5.

The tag is attached with special pliers to an adult salmon while it remains in the water. The salmon is led into a trap four feet square, which contains 1-1/2 feet of water. When the activity of the fish decreases and it maintains a constant position in the trap, the tag is gently placed on the back of the fish two inches behind the dorsal fin and clinched shut in the flesh. This procedure eliminates the necessity of handling the fish with seines or dip nets and of manually holding the fish during the tagging operation. The salmon is released within 30 seconds after tagging and its movements are followed with the receiving equipment. The manner in which the sonic tag is held by the pliers for attaching to a fish is shown in Fig. 6.

Effect on Natural Behavior

In order to interpret data obtained with the sonic equipment it was necessary to determine the effect of the tag on the natural movements of adult salmon. Experiments were conducted in a hatchery holding pond located in a small stream where large numbers of fish were trapped and held for spawning purposes. The pond was 100 yards long, 50 yards wide and averaged 3.5 feet deep. A rack at the upstream end of the pond created an even flow of water the velocity of which was estimated at one-half foot per second.

Sonic tags were attached to adult chinook (O. tshawytscha) and silver (O. kisutch) salmon ranging in length from 1.5 to 2.5 feet which were released into the holding pond. Fish which were active and not ready for spawning were selected for tagging. These fish were removed from a seine used by hatchery personnel to obtain fish for

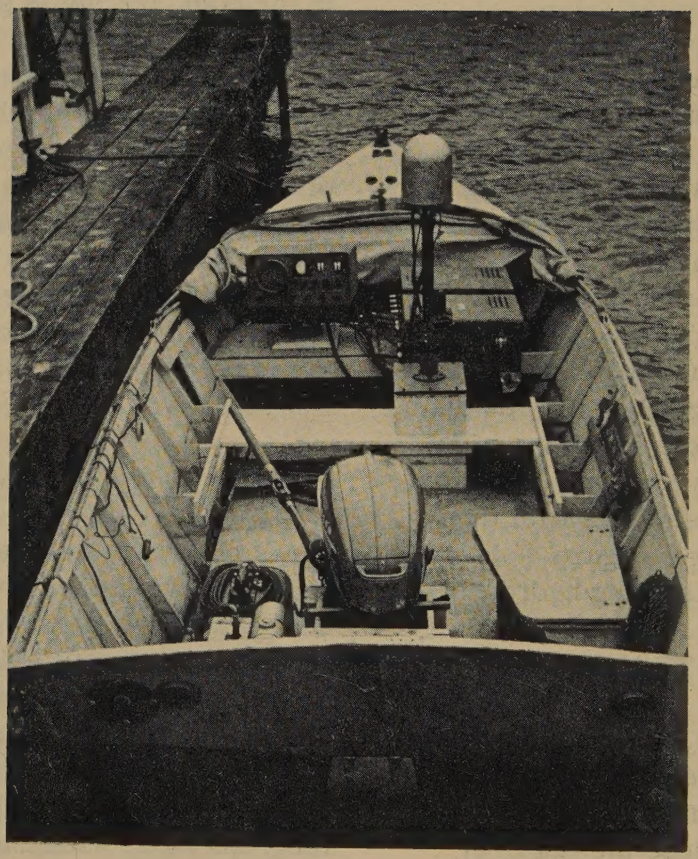

Fig. 3. Automatic tracking receiver installed in an 18-foot Fish and Wildlife Service boat.

Fig. 4. Portable receiver with hydrophone and earphones.

Fig. 5. Hog-ring attachment device soldered to sonic tag.

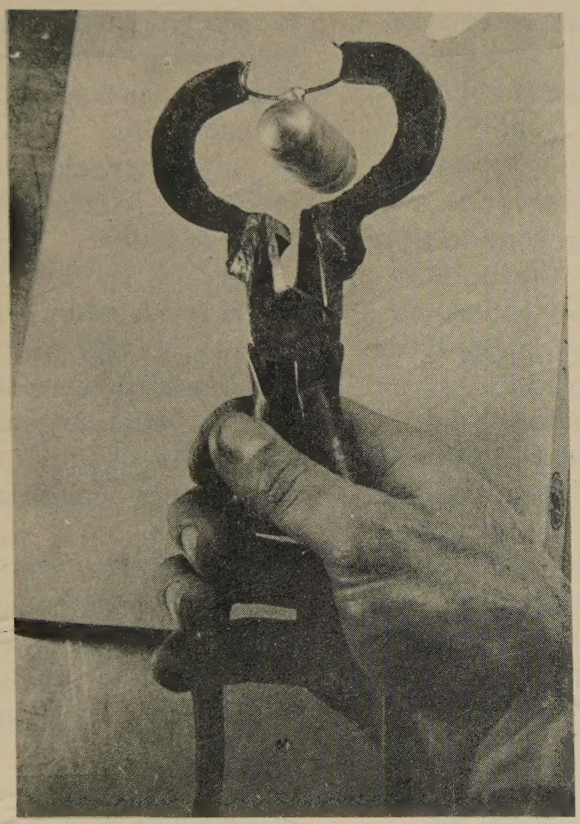

Fig. 6. Sonic tag held with special pliers for attaching to adult fish.

spawning. Immediately after a tag was attached the fish was gently released and its behavior observed. For experimental purposes only, each sonic tag was brightly colored so that it could be easily identified.

Forty fish were tagged in groups of ten over a period of four weeks and their movements observed. The movement of each fish was carefully noted immediately following its release and at one-half hour intervals for the remainder of the first day. Thereafter, the tagged fish were visually located in the pond and their movements observed each day for two weeks.

After being released, their movements were fast and erratic for the first two to five seconds. Following this interval the movements of the tagged fish appeared normal in relation to the movements of the untagged fish. There was no evidence of untagged fish avoiding the tagged fish within the holding pond. The tagged fish swam about freely and did not appear to prefer any specific area of the pond.

In addition to determining the effect of the sonic tag on the natural movements of an adult salmon, these experiments showed that the "hog-ring" type attachment was successful in securing the tag to a fish. During the experiments, the holding pond was completely seined two or three times each week to remove the fish ready for spawning. Although the tagged fish received rough handling during these seining operations, the sonic tags remained securely attached for at least two weeks, after which they were removed.

USES OF SONIC EQUIPMENT

The sonic equipment can be used under a variety of natural conditions to study the behavior of adult fish. In the vicinity of dams, the manner in which an adult salmon locates a fishway entrance or collection system opening and chooses an entrance or opening can be determined. Measurement of the rates of movements of a fish through a fishway can be made and areas where delays occur discovered. By tracking adult salmon as they make their exit from a fishway, the relationship of their movements to spillways and powerhouse sections of a dam can be obtained. Any changes in behavior after passing through a fishway can also be determined.

The equipment also provides a method for studying the movements of adult salmon in a marine environment in relation to climatic conditions, shore lines, ocean currents, etc., as well as their movements as they progress through an estuarial environment during their migration from salt to fresh water.

In fresh water lakes, the equipment may enable biologists to determine adult fish behavior in relation to ecological conditions, and information on their orientation in the selection of a particular stream for spawning purposes.

Although the sonic equipment was developed to provide specific data on adult salmon movements relative to dams, it can be used to supply information on the movements of a large variety of adult fish and aquatic animals under natural conditions. As it is employed, additional uses will become apparent and it will become increasingly valuable as fishery research equipment.

SUMMARY

1. New sonic equipment has been developed for tracking individual adult salmon and observing their movements under natural conditions, in relation to Columbia River dams.

2. A sonic tag is attached to an adult salmon migrant and its movements are observed with calibrated receiving equipmer

that picks up the sound waves from the tag.

3. The sonic fish tag is attached to the fish with a nickel-chromium hog-ring using special pliers.

4. The tag is attached underwater without handling the fish.

5. There is no apparent effect of the sonic tag on the natural movements of the fish.

6. The sonic equipment can be used in fresh or salt water to track the movements of individual fish and other kinds of aquatic animals.

ACKNOWLEDGMENTS

The technical development and production of the sonic equipment was accomplished under the supervision of Roy Malm of Minneapolis-Honeywell Regulator Company while John Dudley was responsible for the design and operation of the equipment.

Thanks are due Charles Ellis, Supervisor of Hatcheries for the State of Washington, for making available adult salmon and an experimental area for testing the effect of the sonic tag on natural behavior. The cooperation and assistance of the personnel of the Washington State Fish Hatchery at Auburn is also gratefully acknowledged.

Appreciation is also expressed to Fishery Research Biologist James H. Johnson for assistance in testing the equipment and photographing the equipment.

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